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USE OF A HARD METAL ALLOY

The invention relates to the use of a hard metal alloy for parts which, in addition to wear, are in particular also subject to torsional loads.

Parts which, in addition to wear, are also subject to torsional loads include, for example, screwdriver bits. Screwdriver bits of this type are received in a holder or directly in the screwdriver handle and generally have a hexagonal holding shank and a tip, also referred to as the output. The shape or profile of the tip is also matched to the shape of the head of the screw which is to be screwed in. In particular screws with slotted heads, with cross-heads of various shapes and with internal hexagon socket heads are in widespread use.

The screwdriver bits are produced primarily from steel, which is generally hardened to a hardness of between 54 and 62 HRC. At this hardness, screwdriver bits of this type made from steel generally still have a sufficient ductility to withstand the torsional loading which occurs during screwing without being damaged.

Despite the relatively high hardness, depending on the profile of the screwdriver bit, rapid wear and damage to the profiled edges and therefore premature failure and/or damage of the screw heads often occurs.

Therefore, in the past it has been attempted to further improve the wear resistance of the surface of the screwdriver bits, at least in the profiled region, by the use of hard-material coatings or soldered-on hard metal reinforcements.

For example, DE 40 29 734 C2 describes the formation of a non-slip coating on screwdriver bits, particles of frictional material being applied from an electrode to the hardened working surface of the screwdriver bit using an arc process.

However, all these measures are complex and expensive, and in the case of the coating, on account of the prolonged action of heat during the coating operation, can damage the microstructure of the screwdriver bit. In the case of the screwdriver bits reinforced by soldered-on hard metal reinforcements, the shear strength of the soldered join is in many cases too low.

Screwdriver bits made completely from hard metal have not yet been employed, on account of objections relating to their torsional strength being too low.

The object of the present invention is to provide, for parts which, in addition to wear, are in particular also subject to torsional loads, a material whereof the properties are superior to the previously known materials for applications of this nature.

According to the invention, this is achieved by the use of a hard metal alloy substantially comprising tungsten carbide with a mean grain size of less than 1.2 µm and 13 to 23% by weight of binder metal, selected from one or more metals from the group consisting of cobalt, iron and nickel.

The use of this special hard metal alloy brings considerable improvements in terms of the wear resistance and, at the same time, excellent results with regard to torsional strength. This was also surprising in particular because, contrary to expectations, it is not especially ductile hard metal alloys which have a good torsional strength, but rather a group of alloys of only below-average ductility. The torsional strength, which is dependent on the specific shape and size of the part produced, is in the range from 1800 to 2400 N/mm^2.

That the alloy substantially comprises tungsten carbide means that small quantities of other hard materials, in particular other carbides, of the order of magnitude of up to

approximately 10% by weight may be present in the alloy without significantly altering the advantageous properties.

A hard metal alloy consisting of tungsten carbide with a mean grain size in the range from 0.7 to 0.9 µm and 13 to 17% by weight of cobalt binder has proven particularly suitable for the use according to the invention.

The properties of the hard metal alloy according to the invention are additionally improved if there is a certain coarse-grain fraction in the hard metal alloy. A level of up to 200 grains/mm^2 with a mean grain size in the range from 6 - 15 µm has proven to be an advantageous order of magnitude.

The coarse-grain fraction is formed by slight over-sintering of the hard metal alloy during production. Without the formation of a coarse-grain fraction, the hard metal alloy according to the invention is sintered at a temperature of approximately 1400°C for a period of approximately 60 minutes. The over-sintering in order to form the coarse-grain fraction is achieved by increasing the sintering temperature to approximately 1440°C and lengthening the sintering time to approximately 90 minutes.

It has proven particularly suitable to use the hard metal alloy in accordance with the invention for screwdriver bits. In this case, despite the notch effect resulting from the special profiled shape of the tip of the screwdriver bits, it was possible to transmit torques of on average up to 20 Nm.

The highest torques that it is possible to transmit are achieved if the screwdriver bits are produced by metal powder injection molding.

For this purpose, granules are produced from the hard metal powder mixture and an organic binder, such as waxes or polymers, by mixing, and these granules are heated in an injection-molding machine at temperatures of between

approximately 100 and 200°C, followed by injection molding into suitably designed molds. After cooling of the mixture, the blanks, which already have an excellent strength, are ejected from the injection mold, and then the binder is removed in suitable furnaces, followed by sintering to form a liquid phase of the binder metal fraction. The volume shrinkage which then occurs is of the order of magnitude of approximately 50%, and the sintered density achieved is virtually 100% of the theoretical density.

The use of metal powder injection molding allows deliberate rounded sections which are already present in the injection mold to be incorporated at edges of the screwdriver bit which are particularly at risk, with the result that, on account of the reduced notch effect at the screwdriver bit, high torques can be transmitted without the risk of fracture.

During metal powder injection molding of screwdriver bits, it is particularly advantageous if a plurality of parallel web-like elevations running at approximately 45° to the longitudinal axis are machined into the injection mold directly beneath the screwdriver tip. These elevations cause a directional flow toward the tip of the screwdriver bit to be imparted to the material injected into the mold, resulting in particularly good filling and a uniform density in this region, on which the highest load is exerted in use.

Furthermore, metal powder injection molding, purely by providing a specific surface condition of the injection mold, permits a specially structured formation of the profiled surface of the screwdriver bit, as a result of which it is possible to substantially prevent the screwdriver bit from slipping out of the screw head even when the pressure exerted on the screwdriver bit is relatively low, thereby extending the service life of the screwdriver bit. An additional boost to this effect can be achieved by the introduction of ultra-hard particles, e.g. diamond grains, in the injection mold, as part of the injection molding process.

The following text provides a more detailed description of the invention on the basis of a production example.

Production example

To test the torsional strength, rod-shaped specimens were produced from a hard metal alloy in accordance with the invention, designated Specimens 1 in Table 1, comprising 85% by weight of tungsten carbide with a mean grain size of 0.7 µm, remainder cobalt. The specimens had a hexagonal profile with a cylindrical center part. The total length of the specimens was 38 mm, with an across width of the hexagonal profile of 5 mm. The cylindrical center part of the specimens had a length of 16 mm and a diameter of 3.8 mm. The resulting cross section of the center part approximately corresponds to the shearing cross section of the screwdriver bits most frequently used in practice.

A block with dimensions of 70 mm × 46 mm × 25 mm was produced on a die press by pressing the powder mixture of the hard metal alloy according to the invention with a pressure of 220 MPa.

The specimens with their hexagonal basic shape were cut out of the center part of the pressed block by means of diamond cutters. Then, the specimens were sintered at 1420° for 60 minutes.

After sintering, the cylindrical center part with a diameter of 38 mm with a tolerance of ± 5 µm was machined into the hexagonal profile of the specimens. The specimens produced in this way were tested for bending rupture strength and torsional strength using corresponding testing devices. The mean values for the bending rupture strength and torsional strength of the tested specimens are listed in Table 1.

For comparison purposes, similar specimens were produced from a hard metal alloy consisting of 75% by weight of tungsten carbide with a mean grain size of 3 µm, remainder cobalt,

designated Specimens 2 in Table 1, and also from a hard metal alloy consisting of 85% by weight of tungsten carbide with a mean grain size of 1.5 µm, remainder cobalt, designated Specimens 3 in Table 1, and finally from a hard metal alloy consisting of 80% by weight of tungsten carbide with a mean grain size of 1.5 µm, remainder cobalt, designated Specimens 4 in Table 1, and were tested for bending rupture strength and torsional strength in the same way as the specimens made from the hard metal alloy according to the invention. The mean values for the strengths of these specimens are likewise listed in Table 1.

As a further comparison, similar specimens were produced from hardened steel, designated Specimens 5 in Table 1. The steel in this case had a standard composition for the production of screwdriver bits. These specimens too were tested for their bending rupture strength and torsional strength, and their mean values are listed in Table 1.

Table 1

Specimens	Composition	Bending rupture strength [N/mm^2]	Torsional strength [N/mm^2]
1 (according to the invention)	85% by weight WC, 0.7 µm Remainder Co	3300	2300
2	75% by weight WC, 3 µm Remainder Co	2500	1200
3	85% by weight WC, 1.5 µm Remainder Co	3400	1900
4	80% by weight WC, 1.5 µm Remainder Co	3100	1350
5	Steel	4400	2300

It can be seen from the table that the hard metal alloy according to the invention has the best torsional strength values compared to the other hard metal alloys. Its torsional strength values are comparable to those achieved by the steel alloy. Since hard metal additionally has considerably improved wear resistance properties compared to steel, the hard metal alloy offers major benefits. It is particularly surprising that hard metal alloys with a high ductility and good or even relatively high bending rupture strength have worse, in some cases even significantly worse, torsional strength values.